outputs channels contain one or more electrically controlled switches and is connected to the two or more batteries; and

[0020] d) managing the available power to the one or more output channels with a central controller so that a sum of charge rates at each output channel adds up to the available charge rate up to the battery max charge rate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] FIG. **1** describes the logical flow of system operation of the present invention beginning with system power on.

[0022] FIG. **2** depicts a system block diagram that describes the major components of the present invention and their connectivity.

[0023] FIG. **3** depicts a more detailed architecture schematic for the charging system of the present invention with select components identified by type.

[0024] FIG. **4** depicts a detailed schematic of the switching circuitry used for each charging channel of the present invention.

[0025] FIG. **5** depicts a detailed schematic of the isolation circuits in the present invention.

[0026] FIG. **6** illustrates an alternative arrangement on the battery pack using the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0027] The battery fleet charging system of the present invention is an electrical device that can be used to charge multiple batteries simultaneously. The device draws AC power from the grid and converts it into DC power that is then supplied to one or more output channels, each channel being connected to two or more batteries.

[0028] Each output channel contains a switching circuit consisting of one or more electrically controlled switches, for example an insulated gate bipolar transistor (IGBT). A controller is used to turn the switches on and off rapidly to vary the output voltage at each channel, and hence the charge current. This process, known as pulse width modulation (PWM), is part of a closed-loop control system whereby the battery pack voltage and current are monitored in real time and communicated back to the controller, which makes adjustments to the PWM to match the charge current or charge voltage set point. The charge voltage set point for each channel can be independently specified, such that battery packs on different channels can be charged at different rates simultaneously, as specified by the user or as hard coded into the charging system firmware.

[0029] The present invention has been designed with sophisticated safety protocols to ensure safety of the user, the batteries being charged, and the charging system itself. As shown in the figures, each charging channel requires communication between the battery and charger, and certain conditions must be satisfied before charging will be initiated. Once all conditions have been satisfied, the charging system sends a request to the battery to close an internal electrically controlled switch (contactor), which establishes an electrically conductive path between the energy storage devices within the battery pack and the external connectors. Likewise, the charging system closes its own internal electrically controlled switch to enable power to the external connectors. Furthermore, if communication between the charging system and battery indicates an unsafe condition, or if communication is lost, the electrically controlled switches revert to the open condition to halt charging. This safety protocol also eliminates the risk of electrical shock at the external connectors when not mated.

[0030] The communications that must take place between the charger and battery can use any method for data exchange. The present invention describes an embodiment that uses wired communication, however, wireless communication can also be used. On each channel, communications are transmitted over a bus. This enables multiple battery packs to be connected to the same channel, in a parallel arrangement. The charging system can identify each separate battery pack connected to the charging channel and communicate with each independently.

[0031] FIG. **1** describes the logical flow of system operation, beginning with system power on. Not shown is the capability to physically add additional battery packs into the system while the system is operating.

[0032] FIG. **2** depicts a system block diagram that describes the major components and their connectivity. This illustration depicts four charging channels, but the number of channels is only limited by the choice of controller(s).

[0033] FIG. **3** depicts a more detailed architecture schematic for the charging system, with select components identified by type. This illustration depicts only two charging channels, but the number of channels is only limited by the choice of controller(s).

[0034] FIG. **4** depicts a detailed schematic of the switching circuitry used for each charging channel.

[0035] FIG. **5** depicts a detailed schematic of the isolation circuits.

[0036] A battery pack voltage varies depending on its state of charge. For example, the voltage will be higher when the battery pack is fully charged than when it is fully discharged. This presents a problem for connecting battery packs in parallel that may be at different states of charge. Current will flow from the battery pack with higher voltage to the battery pack with lower voltage, possibly at an exceedingly high rate due to the low internal resistance of the battery pack. The present invention handles this potential issue by requesting the voltage of each battery pack connected to the channel prior to closing the charge circuit. By having independent control of each battery packs contactors, the charger can charge the battery pack(s) with the lowest voltage first, then connect additional packs as the voltage of the charging packs is brought up to the same level.

[0037] The electronics of the charging system also performs safety checks continuously during operation to monitor for dangerous conditions that may be present in the system. If dangerous conditions are noted they are logged and the appropriate action is taken to prevent a harmful situation being presented to the user.

[0038] The present invention also includes an alternative method to address the challenges described in the previous paragraphs. FIG. **6** illustrates an alternative arrangement on the battery pack. The addition of two diodes on the positive terminal of the battery pack, along with a single pole double throw (SPDT) switch can be used to prevent current flow between battery packs at different voltages. For example, during discharge the SPDT switch is connected to Diode **2**, which allows current to flow out of the battery pack when the voltage of the battery cells is greater than the voltage at